

# The Legacy of the “Cyprus Codex” (MS. Torino J.II.9): Creating New Technologies and Compositions through a Collaborative Process

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## The Cyprus Codex

The Manuscript Torino, Biblioteca nazionale, J.II.9 (known as “MS. J.II.9” from the shelf-marking at the National Library of Turin, Italy, or as the “Cyprus Codex”) is one of the most important collections of French mediæval music and one of Cyprus’ most important cultural heritages. As a Cypriot composer, this collection has served as a constant source of inspiration in my search for my own identity. In terms of its music legacy, MS. J.II.9 represents unique features amidst changing musical styles, and it was composed in the court of Nicosia, one of the last frontiers of Western influence at that time, close to the turbulent crusade regions. Its historical and cultural importance first drew me to explore its content, and this article will discuss the unique historical and cultural circumstances contemporary to its composition and draw valid connections to the current climate before demonstrating how the Codex has inspired me to compose new works and push for technological discoveries. I have been working closely with violin virtuoso Peter Sheppard Skærved for over a decade now,<sup>1</sup> and given our mutual interest in history, it seemed fitting for us to collaboratively explore aspects of MS. J.II.9 while composing a series of new works that are deeply rooted to the town of Nicosia. I will demonstrate and give examples of our recent work and how this has led to an expansion of the collaborative core, incorporating Professor Timothy Hsu<sup>2</sup> and his students to help design new bows and excitors, among other technological innovations.

1. Peter Sheppard Skærved, who contributed important parts to this article, is the dedicatee of well over 400 works for solo violin and is acclaimed for both his collaborative work with museums and his recitals on prestigious collections of historic instruments, like those at the Library of Congress, Washington DC. He is the Viotti Lecturer and an elected Fellow at the Royal Academy of Music, London. He is the only British violinist to have been invited to play on Paganini’s violin // *Cannone* more than once (five times). He records for NMC, Chandos, Naxos, Metier, and Toccata.

2. Dr. Timothy Hsu is on faculty at the Georgia Institute of Technology School of Music. Dr. Hsu received a BMin Piano Performance and in Recording Arts and a MA in Acoustics at the Peabody Institute of the Johns Hopkins University. He completed his M.S. and Ph.D. in Mechanical Engineering, studying acoustics at the Georgia Institute of Technology. His interdisciplinary research focuses on combining musical acoustics, instrument design, music education, and architectural acoustics.

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3. The “Arab Spring,” the recent violent regime changes in the Middle East and the ongoing war in Syria, have all once again given prominence to Cyprus’ strategic position. Royal Air Force fighter jets have used the British military bases in Cyprus for several of their operations in the region.

4. Throughout its history, Cyprus has been under the rule of Egyptians, Persians, Romans, English, French, Venetians and Ottomans, among others.

5. Cyprus was part of the Byzantine Empire until the Crusaders arrived and part of the Ottoman Empire from 1571 to 1878, (from 1489 to 1571, the island belonged to Venice). These two periods, just before and shortly after the distinctly European (French and Venetian) periods, are given much more cultural importance by the two communities in Cyprus. Cyprus has been a divided island since the Turkish invasion of 1974 with a liberal Muslim population (primarily in the north) and a Greek Orthodox majority (primarily in the south).

6. The travels of Pierre I de Lusignan from Cyprus to Europe to raise funds for further Crusades helped disseminate the outstanding reputation of Nicosia’s court musicians and also provide more accounts of the talent of the musicians of Nicosia. The band of musicians from the court of Nicosia who accompanied him were received with great enthusiasm in Europe. Charles V was so pleased by their performances in Reims that he donated eighty francs in gold. Guillaume de Machaut’s epic *La prise d’Alexandrie* is a poetic tribute to Pierre I de Lusignan’s crusading campaigns. In his “Recital Concerning the Sweet Land of Cyprus,” the most important reference to life in Cyprus at the time, Leontios Makhairas mentions that when Charlotte de Bourbon came to Cyprus to marry King Janus I de Lusignan, she brought with her several outstanding musicians (Makhairas

Cyprus is situated at a unique location between three continents and has always been a cross-point of civilizations and cultures. It has truly been a bridge between the East and the West and between Christianity and Islam. This position makes it very relevant, especially today, when one considers the current political climate.<sup>3</sup> Throughout its history, the island’s position made Cyprus a place of strategic importance for the superpowers of the time.<sup>4</sup>

Cyprus was one of the few areas under Western influence in the region amidst the violent period of the Crusades. The arrival of Richard the Lionheart in 1191 ended its Byzantine period, and the following year, Guy de Lusignan’s arrival marked the onset of Lusignan rule (1192-1489), a distinct period in the island’s history when French culture flourished.

The Cyprus Codex comes from this Frankish period of the island, which, despite its importance and length (lasting almost three centuries), still remains fairly underrepresented in the island’s historical records.<sup>5</sup> Art in Cyprus at that particular time in history is inimitable as the island was truly the last frontier of Western authority, influence and rule yet geographically and culturally unique, being so close to Saracen, Arab and Ottoman grasp. The court of Nicosia was a cosmopolitan center, and MS. J.II.9 was composed in a court that was full of intellectual talent and where arts indeed flourished in this most peripheral location of Western influence.<sup>6</sup> It is, in fact, the only known codex of Western music in the region but also still arguably the most important volume of French repertory on the threshold between *Ars Nova* and *Ars Subtilior*.

MS. J.II.9 is believed to have been compiled during King Janus I de Lusignan’s reign (1398-1432), and it still serves as the only complete, substantial documentation from that period, presenting a unique insight into the music that the House of Lusignans was enjoying in its daily life.<sup>7</sup> This compilation presents unique avant-garde features and demonstrates a well-developed musical style, rooted in *Ars Subtilior* yet still with various fluctuations and mannerisms that are unique to the court of Nicosia, making it an important addition to Western music of that period.

The Codex was most likely compiled to serve as part of the dowry for the daughter of King Janus de Lusignan and Queen Charlotte (Anne of Cyprus, as she is known) for her marriage to Louis I, Duke of Savoy in 1434. The compilation of lavish music collections was not uncommon in the late Medieval period, and it is certainly true that this manuscript satisfied the sophisticated artistic taste of the House of Savoy, while adding further prestige to the Lusignan name as well.<sup>8</sup> Anne was responsible for showcasing the court of Nicosia to European courts, and she had bought, among other possessions,

the famous “Shroud of Turin.” In fact, Anne and Louis’s daughter Charlotte later became Queen of France as the second wife of Louis xi. Furthermore, one must not forget that the musicians serving the court of the Savoy at that time were some of the world’s finest, including none less than Guillaume Du Fay. With these facts in mind, it is justifiable to state that MS. J.II.9 is undoubtedly the most important musical heritage to emerge from 15th century Cyprus and perhaps from the entire Levant. The manuscript itself consists of three parts: a chant manuscript, a *liber motetorum*, and a *chansonnier*. It contains monophonic chants, polyphonic mass settings, a special place for St. Hilarion and St. Anna motets, and ballads, among other genres, and it is one of the few (if not the only) exclusively French codex known from the early 15th century. It consists of 159 folios with over 200 (mainly polyphonic) pieces, both sacred and secular in character. The Codex is made unique by the fact that all pieces are anonymous and that each work is a unique copy not to be found elsewhere (in other manuscripts).

Richard Hoppin, one of the most significant scholars of this repertoire, is responsible for helping ignite interest in the Codex with his 1952 dissertation at Harvard University entitled “The Motets of the Early Fifteenth Century Manuscript J.II.9. in the Biblioteca Nazionale of Turin.” A few years later, he published a milestone four-volume edition of the entire Codex with “Cypriot-French Repertory of the Manuscript Torino, Biblioteca Nazionale, J.II.9,” which is still one of the staples of research on the Cyprus Codex.<sup>9</sup> In 1992, a major international congress finally took place in Cyprus with the participation of several scholars who built upon Hoppin’s research with the subsequent proceedings shedding more light.<sup>10</sup>

### A contemporary approach inspired by the Cyprus Codex

There are many reasons why I was immediately drawn to this collection. As a Cypriot composer, I was sadly introduced to this cultural jewel at a later stage in my life. In contrast to other countries, Cyprus’ heritage within the Western sphere is rather limited, and this Codex is part of our unsung tradition. By exploring its content creatively, I have discovered intricacies and details that are still relevant today. Almost six hundred years later, there are many contemporary connections to the Cyprus Codex, not just musical but also social and historical. Much of the history in the region has been shaped by the Crusades, and today more than ever, issues of historic conflict have resurfaced. Attention has been placed on the region yet again for similar reasons, and artists in Cyprus today, not unlike their French-Cypriot predecessors, are creating art amidst similar circumstances.<sup>11</sup>

and Dawkins, [1932]1980). Charlotte, a woman of culture, helped make Nicosia into a flourishing center and, indeed, one of the most important centers of the *Ars Subtilior* style. In fact, King Janus I de Lusignan’s reign is considered the golden age of French culture and art in the court of Nicosia—this, despite major disasters, most importantly, the plague between 1409–1422.

7. The Compilation date of the Manuscript is confirmed by the evidence of a papal bull by the Avignon Pope John xxii issued for the Office to St. Hilarion on the very first pages of the Manuscript.

8. Considering that the House of Savoy was in possession of some of the world’s most precious objects, artistic and otherwise, and had one of the most astounding libraries in the world, the magnitude and artistic value of MS. J.II.9, which was compiled to impress, is easily inferred.

9. See Hoppin, 1960–1963.

10. Gunther and Finscher, 1995.

11. The ripple effect of the “Arab Spring” and the ongoing war in Syria highlights yet again Cyprus’ key position. The influx of refugees to Europe and Cyprus’ close proximity to current warfare makes Cyprus the last threshold of Western influence and a base of operations in the region. The Syrian shores are just a few miles away. Artists in Cyprus are working in a partitioned island in one of the heaviest militarized countries on earth, on the last frontier of Western culture amidst a havoc of instability and uncertainty.

12. Developed primarily by composers centered in Avignon, France in the late 14th-15th century, *Ars Subtilior* was the musical "avant-garde" style of its time, characterized by notational inventions and complexities. The Cyprus Codex is one of the most representative and referenced works of this style.

13. Gunther and Finscher, 1995, p. 484.

In addition, the use of *Ars Subtilior* makes the case to revisit the Cyprus Manuscript even more pressing for today's composers. *Ars Subtilior*, as a style, shares many features with contemporary music, and indeed, representative music from that period still thrills and surprises audiences today.<sup>12</sup> This music is directly connected to the scope and practices of several composers in the 20th and 21st centuries, and it is to some extent responsible for some of the most rhythmically exciting and challenging works ever to be realized before modern times. As Hoppin and subsequently Ursula Günther argue, the Cyprus Codex makes use of invented proportions and new rhythmical complexities that had never been encountered.<sup>13</sup> It was not until the 20th century that music again reached the level of refinement and rhythmic complexities found in the mannerist style.

The study and expansion of rhythm and the appearance of highly irregular proportional expressions as a result of mathematical processes led to the creation of appropriate notational tools. These new tools, such as polymeters, the use of various ink colors and different types of flags and tales, to name a few, not only provided the performers of that time with a more detailed and precise notation and information about the music, but they also offer us today a comprehensive documentation of the music and practices and, to composers, a structural pathway for even further experimentation. There are further links between *Ars Subtilior* and contemporary music: both are highly complex and appreciated the most by a small group of connoisseurs, and both practices still, unfortunately, only function on the periphery of a classical music repertoire that tends to focus on music between the 17th and 19th century. Visually and in terms of scope, the links are also evident, with examples such as the extraordinary canon *Tout par compas suy composés* by Baude Cordier. Contemporary graphic scores and, in essence, the emancipation of notational conventions can be directly traced to such scores. Publications such as *Notations 21* by Theresa Sauer and Mike Perry<sup>14</sup> and the current "fashion" and practice of displaying music scores in galleries as artwork owes a lot to the innovations of that period more than any other, drawing several connections not only with the coloration of scores but also with the shapes and visual stimuli that these provide.

14. Sauer, 2009.

Several composers have, therefore, looked to the past to find inspiration and guidance in creating their technical lexicons. Neoromantic and neoclassical trends have been very successful, and several composers from the New Complexity movement or composers working with algorithmically aided processes and computer-assisted composition have not only been directly influenced by the scope and techniques derived from *Ars Nova* and *Ars*

*Subtilior* but truly also found their forefathers in such styles. The notion of revisiting musical styles, therefore, has always been at the heart of defining and shaping new compositional trends.<sup>15</sup>

In terms of my own work, the study of the Cyprus Codex has inspired me to embark on a creative journey to construct a musical “arc” of six hundred years using the innovative, pioneering aspects of the original music as a guide. My intention has been to create a 21st century manuscript, where newly composed music is interweaved with parts of the Cyprus Codex creating links between transcriptions of the music and newly composed parts. Modern orchestrations and treatises of parts of the Cyprus Codex will meld naturally with original music, aiming to create a bridge between old and modern sounds and a historical bridge to the current musical scene.<sup>16</sup>

My strategy when engaging with MS. J.II.9 has been both to apply techniques used in the manuscript within a more chromatic as well as “spectral” syntax and vice versa (i.e., transfer techniques from my own idiom directly to the harmonic and contrapuntal language of the manuscript). Another strategy has been to transform the sound hierarchy, changing perspectives between foreground, background and middle ground material, all within a context where the listener is still aware of the original material.

In the wind quintet I recently completed entitled *J.II.9 Fragments*,<sup>17</sup> I interweave a *ballade* from the third volume of MS. J.II.9—No. 19, *Je prens plaisir en une dame*—with original material enhanced with the sounds of flexible tubes and harmonicas. These unique sounds are naturally fused with established modern instrumental techniques, creating a narrative where transcriptions, modern arrangements and original material are amalgamated and where various treatises and historical references are naturally fused into a singular sound world.

Here (Figure 1), I use a transcription, orchestration, and then arrangement of *Je prens plaisir en une dame*. The arrangement stays close to the original but also imposes extreme ornamentation, changing of time signatures, frequent insertion of nonharmonic tones, use of additional ornamentation, harmonic reinforcements in orchestration, use of controlled *vibrato* and *smorzato*, *glissandi*, multiphonics, timbral trills, the incorporating of a harmonica in the overall wind quintet sound profile and various methods of acceleration and deceleration, both with symbols and written out parts. The work makes constant use of “developing variations,” and the material is always dynamic and unpredictable in color. The key is also altered to accommodate brighter timbres. An interesting moment of surprise comes towards the end when instead of proceeding with the final cadence, the music departs into a

15. Some of last century's greatest composers, such as Igor Stravinsky with his unmistakable neoclassical style (early 1920s to late 1940s) and more recently Brian Ferneyhough, one of the main exponents of New Complexity who cites *Ars Subtilior* as a great source of inspiration, serve as examples of such practice. In addition, the evolution of Computer Assisted or Aided Composition (cac) software and algorithmic processes owe as much to the work of the 13th–15th century composers' compositional thinking as to recent technological developments. Examples include the development of techniques and functions such as “Rhythm trees” and various ways of accelerating and decelerating as structural devices.

16. The idea of a “21st century manuscript” is still a work in progress. Some compositions, such as the ones referenced here have been composed already, but the complete cycle, which will last several hours and will utilize different forces (instrumental, vocal and electronics) has not been entirely composed at the time of writing.

17. Commissioned by the Chamber Music America Classical Commissioning Program with generous funding provided by the Andrew W. Mellon Foundation and the Chamber Music America Endowment Fund.



site of St. Hilarion's<sup>19</sup> Castle, another architectural jewel that was renovated during the Frankish period.

The Torino manuscript opens with a rhymed Office and Mass for St. Hilarion.<sup>20</sup> Whereas most visitors remember the spectacular views that St. Hilarion's Castle offers, what fascinates me is the noise coming from the airplanes and visitors, filtered through the air like an ethereal cluster of languages and noise. This inspired the incorporation of flexible tubes and various harmonica effects as the means of filtering the sound of the five wind instruments (Figure 2). These details, therefore, offer an insight into not only

19. St. Hilarion was an early Christian monk from Palestine, who was a disciple of St. Anthony the Great and later moved to Cyprus where he is a patron saint.

20. This is the first time that a Mass for St. Hilarion appears in history. An approval to include this Mass in the Manuscript was requested from and granted by the Avignon Pope John xxiii.

**FIGURE 2** Incorporation of flexible tubes and various harmonica effects

47 J.II.9 Fragments

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Fl. *ff* *pp* Take flute. Whistle tones

E. Hn. Take G Tube *f* *mp* *mf* Block the end of tube with palm (air in tube)

B♭ Cl. Take G Tube *f* *mp* *mf* (air in tube)

Hn. Whistle tones *pp* (Harmonica)

Bsn. *pp* *ppp*

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Fl. *mp* *pp* (Block airway from one end with palm or finger) Unpitched sound

E. Hn. *mf* *mf* Block the end of tube with palm (air in tube)

B♭ Cl. *mf* *mf* Block the end of tube with palm (air in tube)

Hn. *mp* *mf* *pp* (air in tube)

Bsn. (Harmonica) *ppp* ("Oy" as in "Oyster", repeat as fast as possible) Mouth placement



21. This composition is due to be completed by mid 2019.

22. Commissioned by New Music USA with support and/or endowment gifts from the Mary Flagler Cary Charitable Trust, Helen F. Whitaker Fund, Aaron Copland Fund for Music, and the New York State Council on the Arts.

23. *Trattato di musica secondo la vera scienza dell'armonia* (1754) and *De principi dell'armonia musicale contenuta nel diatonico genere* (1767) are two of his most important works. Tartini's theoretical work also includes a treatise on ornamentation, *Traité des agréments de la musique* (1771).

24. Three years after Cyprus' 1960 independence from Great Britain, tensions between the two communities on the island escalated to violence. In 1963/1964 a Peacekeeping Force arrived in Cyprus, and Nicosia was effectively divided into zones and, in essence, partitioned. During the ceasefire talks, UK General Young drew a ceasefire line on a map using a green pencil and the name 'Green Line' was coined to describe the subsequent buffer zone. The choice of the green color was to avoid any national or political associations (blue or red, for example, could cause reactions from either community).

25. The violin is retuned down to E flat (IV), A remains the same (III), A is tuned down to F sharp (II), and E is tuned down a semitone to E flat (I) to enable sympathetic resonance on one hand, whilst helping create unusual natural harmonic combinations on the other. Because of the very loose resistance of the bottom string as a result of this specific *scordatura*, when the low open string is bowed with extra pressure, a glissando occurs naturally, with the overall timbre resembling the sound of a muezzin and the beginning of the call for prayer. The musical material described here is then reworked in the piece, and this is reference for the "reorientation" analogy.

the musical elements that have informed the compositional discourse, but also how the spirit, architectural and cultural legacy of the time inspire and shape my own work.

### A collaborative process

In working on such a project as exploring the legacy of MS. J.II.9, it was important to create a truly collaborative network. Working together, violinist Peter Sheppard Skærved, the acoustician Professor Timothy Hsu, and I were able to connect various aspects of past and current technologies and research custom-made technologies in new compositions.

All these concerns will be addressed in my most major work to date entitled *Nicosia Concerto* for violin and string orchestra, composed for Sheppard Skærved.<sup>21</sup> In preparation for composing the *Nicosia Concerto*, I embarked on a series of studies entitled *Nicosia Études*.<sup>22</sup>

For example, demonstrating the use of a copy of Giuseppe Tartini's bow, a bow that is smaller and lighter than modern-day bows yet still very responsive with even more flexibility at the tip, Sheppard Skærved provided me with the necessary information and inspiration to compose the third *Nicosia Étude*, entitled "Ayia (Saint) Sophia," taking its name from the above-mentioned Nicosia church. A product of a workshop with the violinist, the work uses extensive *scordatura*, especially the retuning of the lowest string down to an E flat and using the "Tartini" bow in its performance to facilitate the emergence of delicate details. It is very appropriate that this instrument should be the focus of this experimentation: Giuseppe Tartini left a rich legacy of sonic exploration and two treatises exploring the conflicts and concordances between Pythagorean principles and the emerging understanding of resultant tones and dissonance.<sup>23</sup> The sound of the muezzin travelling across the contentious "Green Line,"<sup>24</sup> the no-man's land that divides Nicosia, has also inspired this étude. In the same way that the church has been "re-oriented" as a mosque, the work oscillates between the distinct drone of the lowest string<sup>25</sup> and the resonance deriving from the unusual tuning. The element of resonance characterizes the first *Étude* as well. Taken from simple harmonic progressions of mannerisms of the 15th century, the *étude* is a study of the resonance and color of open strings and a wide range of harmonics.

The second *Étude* derives from the fourth volume of Hoppin's edition (*Virelais and rondeaux*), No. 26 and takes its title directly from the ballade *Tout vrai solas fery en moi entrer*, which is arranged in its entirety for solo violin with a series of variations. The original material is significantly stretched with frequent uses of microtones, both as coloristic and expressive devices.



In addition, the frequent utilization of the rich sound of open strings (D and A) is a direct reference to the intervallic contour of the opening material. Later in the *étude*, this interval becomes an even more internal and integral structural element that expands the harmonic, melodic and timbral outlook of the work with the incorporation of several harmonics in one of the last variations. Playing these harmonics *sul ponticello* amplifies the scope of the intention further, transforming the original material of the opening fifth into the central principle for the entire composition.

Working with Sheppard Skærved stimulated me to continue the discussion with Timothy Hsu. For example, the demonstration of different bows' effects has encouraged us to explore the possibility of creating custom-made bows and excitors with the help of talented students at the Georgia Institute of Technology. Considering that the core philosophy of the violin has not changed in dramatic ways over the last 450 years, we embarked on a series of conversations to examine previous models. Skærved has performed on several types of violins of various sizes and has provided the team with important information historically, artistically and practically. The violins used for this project so far range from a 1629 Girolamo Amati, a 1685 Antonio Stradivari, to pioneering modern examples, including Luca Alessandrini's "Spider Silk violin,"<sup>26</sup> and the highly sought-after semi-acoustic "Spur Violin," made by Paul Davies.<sup>27</sup> The current traditional violin shares basically the same characteristics described by Philibert Jambe de Fer in his *Academie musicale*.<sup>28</sup> Violins evolved through the emergence of metal and metal-wound strings, higher overall tensions, and changing bass bar designs, resulting in the sound of the "modern" violin. There have been many attempts to modify the violin, as can be witnessed in numerous musical instrument museums around the world. These variations have changed the "f-hole," modified the width of the violin for portability reasons, experimented with the overall shape of the violin, and have even added a horn in the case of the "Stroh violin."<sup>29</sup> Furthermore, the most significant recent modification has created electric violins, instruments that rely solely on string pickups and essentially eliminate instrument resonances and the natural acoustics of the traditional violin. Likewise, the violin bow has maintained the general principle of acoustic excitation—hair exciting the string when bowed across the strings. Throughout the centuries, the curvature of the bow has flipped, the bow has been lengthened and strengthened, and the band of hair widened, amongst some other smaller changes. Due to the great stability of the violin, composers and performers have enjoyed relatively consistent timbres, techniques, and playing styles that have given the violin the sound that it has today.

26. This violin is made out of a blend of silk and resin with three strands of Australian golden orb spider silk. The resulting biomaterial offers both extreme elasticity and durability, as it is five times stronger than steel.

27. This is an engineered semi-acoustic instrument combining amplification while mimicking the resonance of a fully acoustic instrument.

28. See Lesure, 1958.

29. The instrument was invented in 1899 by the German born, London-based electrical engineer John Matthias Augustus Stroh.

Naturally, all these discussions were very important in the subsequent collaborative work, giving the team an informed historical and cultural background upon which to develop. The approach of the design team from the Georgia Institute of Technology was to start to break down these traditional violin and bow features and to rethink how the strings themselves are excited. The eventual goal for this project is to create brand new timbres and sounds that can be achieved through radical bow redesign. Even to call it a “bow” is potentially misleading as these novel designs create sound by bowing, plucking, and striking.

The methodology for these new “bows” has been design-approached. This has been traditionally successful in mechanical engineering design, and we deemed it the most appropriate method to be adopted for the development of hybrid and novel bows. In this methodology, the following are examples of the tables and charts made in the mechanical design process<sup>30</sup>:

30. As the process is iterative, these are living charts that help the designer understand the system in order to develop improvements and changes for advancements in design.

- House of Quality
- Function Tree
- Morphological Chart
- Evaluation Matrices
- Specification Lists

The House of Quality (hoq) is used to identify the needs of the consumer (i.e., a table to understand the needs of the violinist). This chart highlights trade-offs in design and represents the relationship between specifications. This is a useful tool that can provide relative importance between needs and requirements, shaping the next stages of ideation. With the hoq, the engineering requirements can be deconstructed into specific functions, which could be found in the Function tree. Each of the engineering requirements can be used as a root node for the Function trees. The requirements are continually dissected until the clearest basic function is illuminated. The lower nodes of the function represent viable engineering solutions and can be used to complete a morphological chart or be used to brainstorm mechanical elements.

Brainstorming and morphological charts are ways to generate ideas and create theoretical systems for functionality. Evaluation matrices and specification lists are generated from this iterative process. Based on our design process, three bow systems were prototyped, 1) multi-surface bow (msb), 2) the hair-replacement bow (hrb), and 3) the rotating motor bow (rmb).

The multi-surface bow (msb) comprises four different options for excitation of the string. The objective of this bow is to provide a lightweight system that

gives the violinist many different passive options while playing. These options are surfaces rigidly attached to the bow and include, 1) pluckers, 2) variable density bristles, 3) a wood strip, and 4) velcro-like tubes. The pluckers, short and stiff plastic “teeth” that extend just a few millimeters from the bow, allow the violinist to play in a continuously plucking fashion. In implementation, this was achieved through the use of a hair comb. The bristles are comprised of longer and less stiff brush-like elements. The density of the brushes can be variable, allowing for timbral ranges from a sparse tone to a *spiccato*-type of bouncing. The third option is a lightly serrated, thin density wood strip. The serrations allow for a time-varying tone, and the thin density wood simulates a high frequency filter sweep. The last option consists of small flexible plastic tubes that resemble the hard side of Velcro strips. When attached to a rigid surface, this results in a timbre that attacks the string less than the pluckers but still results in plucked sounds. All four surfaces are placed on a short bow skeleton that allows for easy transitions from one to another. The surfaces are placed on three of the four sides of the bow at a 270-degree rotation, which is not challenging for most violinists. The msb is shorter than traditional bows so as to reduce the perceived weight of the bow. This allows for greater maneuverability for the violinist. The msb balances ergonomics and playability with a variety of new sounds through new rigid surfaces.

The hair-replacement bow (hrb) consists of a multi-surface bow that replaces traditional horsehair with other found objects that are played along the length of the surface. The playability and ergonomics resemble traditional bowing, but the timbre is altered through these various surfaces. These materials that replace that horsehair are: 1) leather, 2) synthetic woven materials, and 3) rubber. Each material gives a unique sound to the instrument. The leather gives a more uniform sound but also highlights the texture of the leather well. This variation in sound can be controlled through the selection of type and finish of the leather. The synthetic woven material possesses a unique quality in that the weave pattern and density contribute to a low frequency variation in the sound. The timbre will consist of both frequencies, that of the string and that of the texture of the woven material. The rubber material provides a homogeneous, uniform sound that is variable with rosin usage.

Additionally, three or four strings can be played simultaneously when the bow extension is added. This bow allows for a wide variety of sounds without necessitating large changes to the traditional bowing technique. The main challenge of this bow is the management of weight and balance. As it is approximately the same length as a traditional bow, the several surfaces that

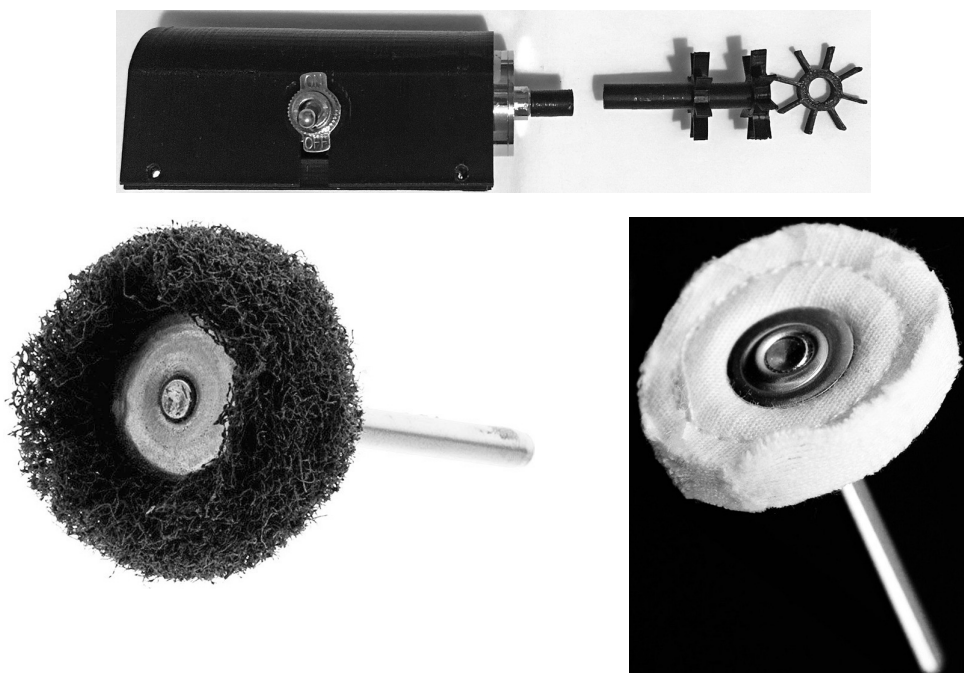
it provides add weight that can require more effort from the violinist. In addition, it is worth mentioning that the earliest representation of what would become the violin bow, when used on Citoles and Psalteries, depict an object which could be crucially used as both a striking and a stroking instrument, a beater and a bow. The notion of *col legno*, and indeed of historical “extended techniques,” can be read as memories of this early string instrument *techne*.

Another element that was equally inspiring and influential can be traced to the study of early keyboard technologies and especially the wealth of hammer surfaces that can be found. For example, researching the evolution of keyboard instruments from the early fortepianos to the modern pianos, we can see the evolution and development of materials and actions. The change from leather to felt is one aspect of such evolution. Our working process has been equally invested in the proven methodologies of the past as well as the exciting possibilities that present technologies can offer. The input of Peter Sheppard Skærved in this respect was crucial in helping the team identify suitable materials and has also inspired me to experiment with different materials.

Lastly, the rotating motor bow (rmb), currently in its final stages of design, changes the paradigm of bowing to an electro-mechanical device that excites the string. The prototype of the motorized bow consists of a motor, a connecting rod, and rotating plectrums. This battery powered motor provides the musician variable speed control (Figure 3).

However, motor selection is crucial as a small motor may not have enough torque to overcome the pressure on the strings, and a motor with too much torque may be unwieldy and loud. The playing surface of the rmb consists of 1) the connecting rod and 2) interchangeable ends. The connecting rod itself is at a slight angle, and this angle produces a rhythmic percussive sound. The interchangeable ends can consist of a variety of materials, ranging from felt, wire brushes, and plastic pluckers. The violinist can create a variety of tones from just one attachment. Whereas the hrb and the msb have easy transitions between surfaces, the transitions with the rmb can be more difficult if the ends need to be replaced. This handheld bow does not resemble a traditional bow and will potentially require the development of new techniques and arm positions for the violinist. Therefore, the challenges here in selecting the most suitable motors have been finding a balance between reducing the weight, addressing the issue of a good balance point, offering the violinist an intuitive experience, reducing the amount of noise coming from the adjustable motor and placing the controls where they are easily reached while simultaneously concealing parts of the mechanism to have an elegant and aesthetically pleasing result as well.

FIGURE 3 Rotating motor bow: Mechanism and striking objects (Rotary tool Accessory Set)



One of the strengths of this project, from my point of view, has been uniting teams from different and diverse backgrounds as well as having a team with strong expertise in their respective fields. In addition, having a group focusing on the technological needs and another on the musical implementation of these ideas has also proven to be very important. Several teleconferences between Central New York, Atlanta and London, where the members of the team reside, took place in the context of the past two years to enable this. I visited Atlanta five times in order to meet with the team and met with Sheppard Skærved on numerous occasions on both sides of the Atlantic. Having a team discuss various possibilities with a performer that has a strong record of both working with living composers and a formidable knowledge of the development of string instruments and bows, among others, has helped spark our research into new directions.<sup>31</sup> Therefore, finding the right balance between functionality, practicality, the desired sound, and ergonomic economy could not have been possible without these three constituents, as one member completes another's area of expertise.

31. In fact, Peter Sheppard Skærved was one of the first champions of both Luca Alessandrini's "Spider Silk violin" and Paul Davies' "Spur Violin." His feedback and experience of premiering hundreds of new works and working with some of the greatest composers of the 20th century has given both the technology team and me concrete inspirations. In addition, his input on aspects of aesthetics was crucially important.

This type of collaboration has helped create fascinating results and generated additional intriguing research questions. How can the process of working with performers with a profound knowledge of the repertoire and early music performance practices, techniques and innovations enhance or change performance qualities of newly created music? How can extended instrumental techniques be incorporated within an alternative tonal syntax found in early music? How can the creation of new methods of playing the violin and the development of new types of excitors and bows influence the conception of new methods and techniques for playing the instrument, and how can some of these possibly enter a more mainstream domain that can engage and ignite the interest of bow makers? These are all research questions that are examined through a theoretical, scientific, performance, musicological and compositional lens. It is an ongoing process, and this paper is a photographic depiction of its current stage.

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